# Mobile Gateway for Wireless Sensor Networks utilizing drones


***Abstract*—Mobile Gateway for Wireless Sensor Networks utilizing drones**

**Wireless Sensor Networks have good uses in applications running in remote locations, where maintenance is difficult. WSN islands often need a connection with a gateway in order to communicate with the outside world, but this cannot be provided in all circumstances. A different approach to connecting wireless sensor networks is to use mobile gateways that can reach the remote locations where WSN are running. Our design offers a mobile gateway that is the solution to the problem by using a SparrowDongle gateway node connected to a Parrot quadcopter Drone. This system allows us to collect data from nodes along the flight path of the drone, possibly reaching locations where a standard 3G connection can not reach.**



***Index Terms*—gateway, wireless sensor networks, drone**


## I. Introduction

Wireless Sensor Networks are being used more and more in almost every field imaginable. Applications generally involve collection and processing of data, either on-site or remote. Applications fields include home automation, agriculture, military, space exploration etc.[2] In order to collect the data, gateway platforms [5] are required and most of them are stationary bulky devices or PCs connected to one of the wireless nodes that serve as a base-station.

We aim to show in this paper that there exists a solution for a truly mobile gateway design that can be used either for collecting data or for debugging large wireless network infrastructures. Our solution involves a system that includes a high-mobility device (such as a quadcopter drone) and a WSN island comprised of nodes that collect data, but are able to store a limited amount of data until the data can be forwarded to the mobile gateway.[6]

We have connected to an AR Parrot Drone 2.0 a SparrowDongle device [7], a USB stick featuring two micro controllers that can connect to 2.4GHz Zigbee nodes or to our own node design Sparrowv3.2. We will show an overview of the system architecture in Chapter II, the hardware and software implementation in Chapter III and results of using the gateway in Chapter IV.

## II. System architecture

The classic way of implementing a gateway is by using stationary devices or mobile devices like laptops or phones connected to at least one wireless node. The problem with this type of mobile devices is that you have to be in close proximity of the node in order to communicate with it. This might not be a problem if the nodes are easily accessible, but if a node is situated in a remote location (e.g. at a high altitude or over a cliff, or even at an unknown location), using drones seems to be the best alternative.


Figure 1. SparrowDongle connected to AR Parrot Drone 2.0

Having this to say, our design has a number of features useful in everyday interaction with a wireless node outlined in II-A,II-B.

They can be launched from anywhere, fly to any place a node might be placed and gather all the information collected by the nodes.

Additionally, a number of design features were included for ease-of-use in research and development, outlined in II-C,II-D.

### A. Ease of interaction

The drone automatically detects and initiates a communication with a nearby node. It searches permanently for any signal emitted by a node and sends an acknowledgement packet back to it when it receives any signal. After this first handshake is complete, the node has green light to transmit the information to the gateway installed on the drone. If a node has been detected, the pilot is informed of its presence and if the data transaction completed successfully so that he may continue in the search for another node.

### B. Proximity function

The SparrowDongle can supply informations regarding the nearby nodes by reading the strength of the received signal. Using this information, the pilot can direct the drone closer to the nodes location, either for a faster transfer or to find its exact location[8].

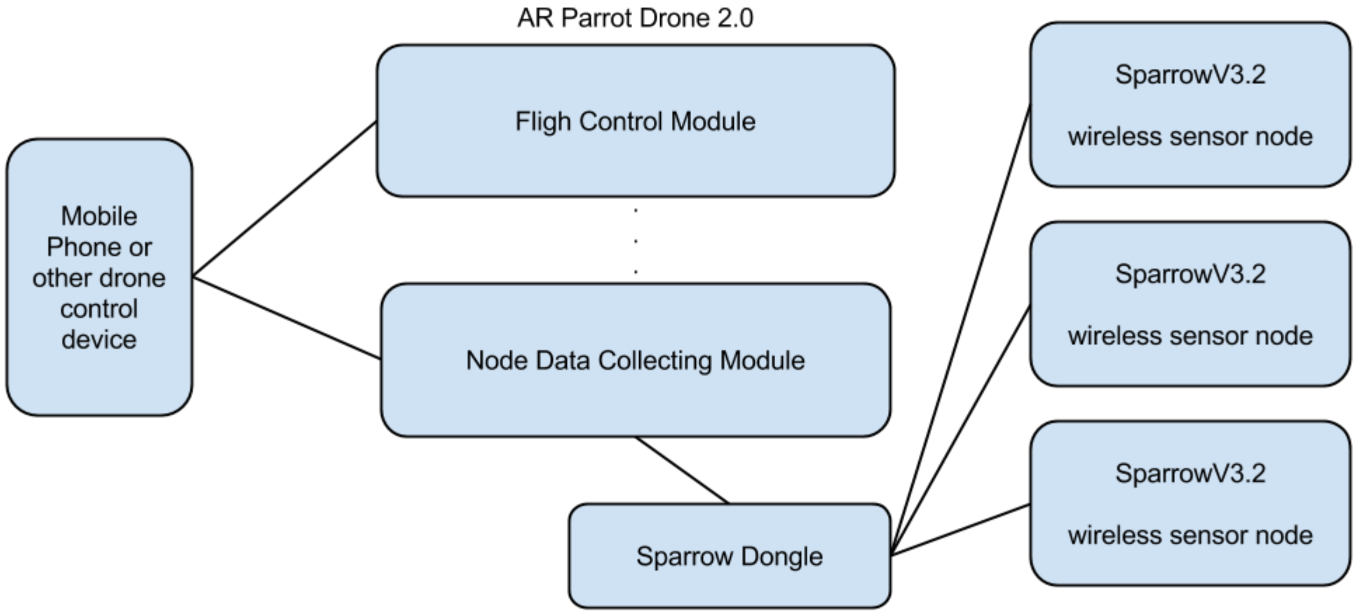


Figure 2. Modules and connection between them and devices

Besides the signal strength offered by the SparrowDongle, the drone features an on board camera with a resolution of 1280x720 pixels streaming at 30 fps. This is very useful in determining the exact location of a wireless sensor node.

### C. Energy Saver

Due to the communication protocol implemented, the SparrowV3.2 node uses very little power when not connected to the drone. It broadcasts just a small packet at fixed intervals for low consumption, and enters on a high bandwidth mode when it detects the presence of a drone for a fast data transfer.[3]

### D. Latest Data

The data is stored on the flash micro controller of the node. In this way, the data is persistent in the memory even the power drops and can be recovered when the power is restored. When the memory is full, the oldest data is deleted in order to make space for new one. The data sent to the drone is from the oldest to the newest, so that in the event of a connection lost the node has free space for new data.

## III. Implementation

### A. Hardware Details

The hardware components used are the following:

- a SparrowDongle with two micro controllers: The 8-bit ATMega128RFA1 which has an on-chip 2.4GHz wireless transceiver and the ATMega32U4, both from Atmel.
- a SparrowV3.2 with an ATMega128RFA1 micro controller
- a AR Parrot Drone v2.0
- an laptop or mobile phone with android/ios for controlling the drone

Because of the addition of the SparrowDongle, the drone's polyester hull has had to been carved a little in order to accommodate it.

### B. Software Implementation

The parrot drone, with a Linux based operating system, allow the software to be organized in different modules. The modules can be modified individually to add more features to the system.

The SparrowDongle gateway dumps every data received on the serial. It is always in a listen for data state. When it receives the data, it sends back an ack to let the SparrowV3.2 node know that it can begin sending the entire data to the mobile gateway.

The SparrowV3.2 node is sending periodically a small data packet to check if a gateway is available. When it receives the ack for the packet it starts sending the stored data to the gateway. The data sent can vary, from sensor readings, to debugging informations in order to check the state of the Wireless Sensor Network.

The data gathered by the gateway is saved into different files the AR Parrot Drone's internal memory. The file also contains informations about the node identification tag and time of the


Figure 3. FreeFlight 2.0 with added WSN capabilities

transfer. The data can be accessed at any time by any device connected to the drone's wireless network via FTP.

All the collected data is processed on the drone. It awaits a socket connection in order to start sending informations regarding the state of the connected nodes.

The nodes can be programmed in order to determine the signal strength of the surrounding nodes, data that is sent to the drone in order to determine the approximate location of the nodes[4].

## IV. Results

In this chapter we will cover the results obtained with this gateway platform.

### A. Performance

The platform can detect multiple wireless sensors and offer real time feedback. The delay is small, but it can vary directly proportional with the distance between the drone and the phone and between the drone and sensor. Usually, this delay can start from 10 ms and pass 150ms for high distance connection. Also, thanks to the transmission speed of 250kbps, big data is transfered in under 3 seconds. After the transfer is complete, it can be uploaded to the remote sever for further processing.

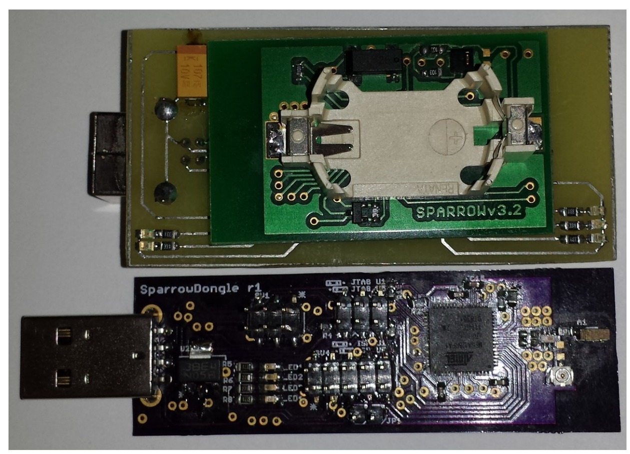


Figure 4. SparrowV3.2 and SparrowDongle

### B. Hardware

Because the drone has a powerful arm processor, it can do most of the processing required to fly and to detect and collect data from nodes. By using this approach, even when the drone loses connection to the mobile phone, it can hover on its own until the connection is reestablished.

The dongle fits tightly between the body and the shell of the drone. This can represent a future problem on different types of drones where a smaller dongle may be required.

### C. Software configurations

The software solution is very versatile. It can be ported on every platform and programing language that supports sockets, also the dongle and the nodes ca be reprogrammed following the application specifications in which they are used.

At the moment, the following modes of operation are available, but more are to follow:

- *Node discovery*: Nodes can be discovered and located easily when the drone is in proximity.
- *Data server*: This mode allows the drone to save the data and to be accessed even when the drone's power supply is removed or it is not flying or connected to any node

## V. Future work

The versatility of the platform makes it ideal to be deployed in a wide range of applications, especially those of which environment is dynamic.

For instance, some possible applications in which the drone can be deployed are [1]:

- Autonomous collection of data data by adding a gps receiver to the drone and setting path way points to follow
- Debugging a wireless sensor network by checking which node is working, the connection logs and the physical state of the device
- Search and rescue operations, especially when going skiing in a avalanche prone environment by wearing a wireless sensor.
- Creating a small wireless sensor network for a limited time with small costs and large battery life
- Treasure hunt where the sensors can hold the clues that lead to the location of the treasure

## VI. Conclusion

The paper presented an innovative mobile gateway platform for wireless sensor networks that offers the ability to interface sensor networks in a novel way.

The platform is easy-to-use and customize to meet the different needs of applications. The system is able to collect data from a Wireless Sensor Network island and offers a potential drone operator realtime data concerning nodes in proximity. The system uses the Parrot AR drone and is decoupled from the piloting module, allowing different piloting schemes to be used with it (i.e. the drone can be piloted anywhere, with or without an operator and it will collect data automatically).

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